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part of the work has been accomplished by the help of grants received from the Government Grant Committee of the Royal Society, to whom I wish here to express my gratitude. If it is to be continued on the same scale it can only be by means of further assistance from the same source, and it seemed very desirable that an effort should be made at the earliest possible opportunity to ascertain to what extent the investigation is likely to increase our knowledge of the Moon.

There is another reason why the attempt should be made to determine the individual altitudes with all possible precision. It has been frequently suggested that measures of well-defined points upon the Moon's surface should be made with meridian instruments, instead of measures of the limb, in order to determine the position of the Moon. In order to compute the apparent position of a point on the surface relatively to the centre of the disc at any given instant it is necessary to know its selenographical coordinates in all three dimensions if full advantage is to be obtained of the increased accuracy of which I believe the method to be capable.

The same knowledge will be required if we are to adopt photographic methods of determining the Moon's position as has been proposed by Professor Turner (*Monthly Notices R.A.S.* vol. lxiv. p. 19).

The Spectroheliograph of the Solar Physics Observatory.

By William J. S. Lockyer, M.A., Ph.D., F.R.A.S.

Introduction.

Since the year 1897 numerous experiments have been made at this observatory to determine the best design for a spectroheliograph based on the Hale-Deslandres principle. The improvised instruments took many forms during the course of the trials, until finally, in 1901, the definite form resulting from these experiments was decided upon and the instrument purchased.

In the present paper it is proposed to describe somewhat in detail the instrument now at work, and give a brief account of some of the first results which have been obtained during the past year.

The principle of the spectroheliograph may first be described briefly. Imagine an ordinary student's spectroscope with a collimator and observing telescope, but with the addition of a plane mirror in the optical train to render the collimator and telescope parallel to each other. Replace the eyepiece of the observing telescope by a slit (secondary), thus providing a means of isolating any small portion of the spectrum. If now an image of the Sun fall on the slit (primary) forming part of the

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collimator, then the light passing through the secondary slit will only consist of a small part of the spectrum corresponding to the slit's width. By adjusting the secondary slit so that only one line in the spectrum, such as H_β, is allowed to pass through it, we shall have an image in hydrogen light of that part of the solar image that is passing between the jaws of the primary slit.

By moving the primary slit, and with it the whole spectroscope, across the solar image, different strips of the latter pass consecutively through the collimator, and consequently corresponding strips in hydrogen light will find their way through the secondary slit. If the solar image be kept stationary, a fixed photographic plate placed nearly in contact with the secondary slit, and the whole spectroscope moved parallel to the plane of the slit plates and in an east-and-west direction horizontally, a picture of the Sun is built up in hydrogen light on the sensitive plate.

The form of instrument in which the solar image and photographic plate are kept stationary is perhaps almost the ideal. There is no restriction to the size or weight of the spectro-heliograph, for the only motion required is that in a horizontal direction, and this can be secured without great difficulty.

In their account of the Rumford spectroheliograph Hale and Ellerman * pointed out that it was impossible to use an instrument of this kind with the 40-inch refractor, since the great weight of the moving parts would have set the telescope in vibration. In place of this the principle of moving the Sun's image across the primary slit by a uniform motion of the telescope tube in right ascension was adopted, the photographic plate being moved at the same time and rate across the secondary slit. In the Potsdam spectroheliograph, a brief description of which has recently appeared,† the instrument is mounted on a Grubb refractor, and the collimator and camera tubes are moved against a fixed solar image and photographic plate.

In all the preliminary experiments made at the Kensington observatory to determine the most suitable form of instrument, that employing a fixed solar image and photographic plate was always used and finally adopted; the present instrument has been designed on these lines.

The complete instrument as now erected consists of three parts:

1. A siderostat to throw the solar beam in a southerly and horizontal direction.
2. A lens placed in this beam to form the solar image.
3. The spectroheliograph to photograph in monochromatic light the image thus formed.

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* *Publication of the Yerkes Observatory*, vol. iii. pt. 1, 1903, p. 6.

† *Astrophysical Journal*, vol. xxi. No. 1, 1905 January, p. 49.

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The Siderostat.

This instrument does not differ in the main from an ordinary Foucault's siderostat except in point of size. It was constructed by Messrs. T. Cooke & Sons, York.

The massive base (6 feet $3\frac{1}{2}$ inches × 3 feet 1 inch) is supported on three large screw-heads each of which rests on a circular iron plate embedded in concrete. On the north side an antagonistic screw arrangement is attached to allow of an adjustment of the base in azimuth. The highest portion of the instrument is 7 feet $4\frac{1}{2}$ inches from the surface of these plates, while the centre of the horizontal axis on which the mirror moves is 4 feet $5\frac{3}{8}$ inches from the same level. The mirror itself is 18 inches in diameter and $2\frac{7}{8}$ inches thick, and was ground by the late Dr. Common. The mirror, cell, and projecting arm are counterbalanced by two levers carrying weights the ends of which are fitted at the back of the cell, two points in the mirror fork being used as a fulcrum for each. The driving clock is of the ordinary Cooke construction, and the weights are suspended over strong wooden gallows fitted close to the north side of the instrument. The clock is fitted with a Russell control, and this is operated from the spectroheliograph room by an electric pendulum made by Sir Howard Grubb. A four-volt cell is used to drive the pendulum, while two cells of four volts each supply the sparking current which operates the controlling armature.

The same two cells are also employed for actuating the two small motors connected by tooth-wheeled gear with the right ascension and declination axes for supplying slow motions in these two coordinates. The switchboard for this is situated in a convenient position on the concrete pillar supporting the spectroheliograph plate-carrier, together with the north foot of the fixed triangular framework, in order that the observer at the secondary slit can adjust the solar image in relation to the primary slit.

To inform the observer when the siderostat driving clock requires re-winding, an automatic electric arrangement rings a warning bell in the spectroheliograph house.

The instrument is sheltered in a wooden house the upper portion of which is on wheels, and can be moved on rails towards the north when necessary.

The Object-glass.

When the instrument was first set up a 6-inch Taylor lens of 20 feet focal length was employed, but this has been replaced by a 12-inch photo-visual Taylor objective having a focal length of 18 feet. It is mounted in a metal cell which is carried by a stout vertical mahogany frame fitted with a vertical adjustment for raising or lowering the object-glass, and adjustable in a horizontal direction for focussing purposes. This frame forms

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part of a strong base resting on a concrete pillar. The object-glass lies to the south of the siderostat at a distanc of 40 feet 4 inches, and forms an image of the Sun of $2\frac{1}{6}$ inches diameter on the primary slit plate.

The Spectroheliograph.

The Slits.—The primary slit was made by Messrs. Ottway & Co., Ealing (Plate 9, fig. 1). It is constructed of brass, and has straight jaws of platinum-iridium 3 inches in length. These jaws are mounted on two small arms pivoted at their middle points so that the milled-headed screw by which the width of the slit is varied operates both jaws simultaneously. The slit plate is mounted at one end of a brass tube, and is capable of rotation in a vertical plane; there is, further, an adjustment for focussing by which this tube can be moved in and out of the collimator tube, the different positions being read off by an attached scale. Behind the slit, but operated from outside the brass tube to which it is attached, is a small exposing shutter. On the slit plate itself a temporary artificial dust mark has been improvised consisting of a needle the point of which is easily adjusted by means of a screw to just cover a small part of the middle of the open slit. The object of this is to give a datum line in the resulting picture for purposes of orientation of the solar disc.

To obtain photographs of the chromosphere and prominences a zinc disc, shown in position in Plate 9, fig. 1, a trifle smaller than the solar image, is placed close up to but not touching the slit plate, and retained there by a thick metallic wire arm rigidly secured to a small wooden block sliding in another block with V grooves. This latter block is capable of rotation in a horizontal plane, but otherwise firmly fixed to a support resting on the same concrete base as that on which the plate-carrier rests. The disc is placed friction tight on to the wire, so that other discs of various sizes may be substituted should occasion occur. During exposure this disc becomes exceedingly hot, so that it must be made of metal and either riveted or fixed on its support friction tight. To allow for the expansion of the metal the solar beam is allowed to fall on the disc some minutes before the position of the image is finally adjusted.

The secondary slit (Plate 9, fig. 2) is somewhat more elaborate than the primary. It was constructed by Messrs. Hilger. It is constructed mainly of gunmetal and brass, with the exception of the slit plates, which are of non-corrodible metal. It is supplied with four adjustments in a vertical plane—namely, a movement of rotation, an adjustment in the vertical and horizontal directions, and the movement of one jaw relatively to the other. For focussing purposes it is capable also of an adjustment bodily in a direction at right angles to the slit plates.

In order to be able to utilise at some future time the instru-

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ment for photographing sun-spot spectra when a large grating becomes available, the two slit plates with the metal slides can be removed entirely from the metal-carrier, and easily replaced afterwards, without deranging any of the previous adjustments of the position of the slit relative to any particular spectrum line.

The jaws of the slit are 3½ inches long and curved to a radius (48·38 inches), corresponding to the curvature of the "K" line of calcium.

Professor Hale, in the description of the Rumford spectroheliograph, adopted the method of dividing the curvature equally between the primary and secondary slits. A careful examination of the images formed by the South Kensington instrument has shown that any distortion which might arise from the method there in use is so inappreciable that it may practically be considered to be non-existent.

In order to allow the photographic plate to be placed nearly in contact with the slit plates, and clear of all projections, every part of the mounting and screw adjustments of the latter are retained on the tube side of the plane of these plates.

The Plate-carrier.

The plate-carrier, which was made by Messrs. Watson & Sons, consists of a vertical framework of mahogany carrying a second framework of similar wood sliding in grooves and capable of adjustment in a vertical direction, the clamping being performed by means of a milled nut (Plate 9, fig. 1). The whole of this framework has a strong mahogany base fitted with three levelling screws, resting on another mahogany base connected by rack and pinion to a heavily weighted box placed on a concrete pillar. The dark slides, made of mahogany and aluminium, are inserted horizontally in grooves on the vertical framework.

The draw slide is of thin aluminium, and fits in aluminium grooves. The inner portion of the dark slide is specially constructed so that the film side of the photographic plates is as close to the slide as possible. This is imperative, since the jaws of the secondary slit and the film of the photographic plate must be placed as near together as is practically possible.

The Optical Parts.

The two slits to which reference has just been made are mounted at one end of a double tube 6 feet long; each tube is rectangular in section and made of mahogany. At the opposite end are placed two 4-inch photo-visual Taylor lenses, each of 6 feet focal length and fixed permanently, the adjustment for focus being made at the slits, both of which are movable in and out of the tubes. In the optical axis of the collimator, but 16½ inches to the south of the collimating objective, is placed a

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6-inch plane mirror (Plate 9, fig. 3) held in a brass frame supported on three levelling screws. To preserve the surface when the instrument is out of use a glass cover is placed over the mirror without disturbing any of the adjustments. Close to the camera lens is a 6-inch Henry prism of 45° angle supported on a wooden base, also on levelling screws. The whole of this end is inclosed in a blackened cardboard box, which is easily removed when necessary.

In this way the light which falls on the primary slit is rendered parallel by passing through the collimating lens; it then falls on the plane mirror, is reflected at an angle on to the surface of the prism, and after passing through the prism falls on the object-glass of the camera, the spectrum being formed in the plane of the secondary slit. Thus the total deviation of the beam for "K" is 180°.

To avoid internal reflexions diaphragms are fixed both within the collimator and camera tubes, and others are placed on the baseboard carrying the prism and reflector. The length of spectrum between F and K is 1·62 inch, so that the dispersion is sufficient if only the "H" and "K" lines of calcium be employed. For work with other lines and for spot spectra it is proposed to replace the reflector by a grating, but up to the present time it has not been possible to obtain one of the required size.

In one of the accompanying figures (Plate 9, fig. 4) is given a reproduction (enlarged twice) of the "H" and "K" region of the spectrum, showing the curvature of the lines. A spot region had been previously adjusted on the primary slit, so that the dark band crossing the spectrum is due to the spot absorption. Reversals of the "H" and "K" lines may also be seen above and below the darkest portion of this band.

The Moving Platform.

The satisfactory working of the spectroheliograph depends largely on the efficiency of the moving platform on which the optical parts are placed (Plate 10). This part of the instrument was constructed by the Cambridge Scientific Instrument Company, and has given great satisfaction.

It consists, in the first place, of a triangular iron framework resting at its three corners on levelling screws, each of which is supported on a concrete pillar. The long side of this triangle rests on levelling screws lying in a north-and-south direction; the third foot is situated towards the west. On the upper sides of this triangle, and near each of the angles, is fixed a small plane-surface steel plate adjustable on the framework by means of four screws. On each of these plates a small steel ball, with a diameter of one inch, is free to move within prescribed limits in any direction.

A similar triangular framework, but with the three similar

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adjustable steel plates fixed to its lower surface, is placed on the top of the first framework, the three balls running between the surfaces of the corresponding steel plates at the corners. To control the direction of motion of the upper framework a guide-bar is fixed on the lower one lying horizontally east and west. Against this the upper framework, which is fitted with two metal struts projecting downwards, is pressed against the guide-bar by two small levers, each having a roller on one arm running on the opposite side of the guide-bar and a small weight suspended on the other arm. These weights keep the metal projections in contact with the guide-bar. The motion of the upper framework is obtained by means of a steel band, one end of which is fixed to the west corner of this framework, while the other, after passing over a pulley fixed to the lower framework, carries a set of weights. To regulate this motion from east to west the upper framework is fitted with a metal plunger which projects downwards and fits into a slot forming part of a piston in the regulating oil cylinder firmly supported on the lower framework. This piston consists of a hollow cylinder open at one end and at the other two apertures, one comparatively large, with a valve to allow the entry only of the oil from the larger cylinder; and the other, variable in size, for the outlet of the oil from the piston during the movement of the framework. The open end of this cylindrical piston moves in and out of a closely fitting cylinder closed at the other end, so that the oil which is inclosed in them can only find its exit through the opening of variable aperture. A milled-headed micrometer screw and scale moving with the slot into which the plunger fits and attached to the piston varies the size of this oil outlet and allows perfect control of the escape of the oil from the inside of the piston to the cylinder without. For the purpose of setting the framework into its starting position, it is pushed towards the east by means of a long screw with attached handle working in a thread fixed in the same upright that carries the pulley. When the starting position has been reached, a small catch-lever fitted to one end of the piston falls into a slot on a projection inside the oil cylinder. This holds the framework in position, so that the setting screw is freed and can be wound back again. The actual starting of the motion is operated by a starting-handle attached to a long metal rod passing through the upper framework which raises the catch-lever out of its slot, and thus releases the piston. The framework thus being set free the weights pull it over in a westerly direction, and the piston pushes the oil from one cylinder to the other through the orifice the aperture of which is controlled by the adjusting micrometer screw. The maximum length of run which can be obtained by the motion is four inches.

With regard to the actual quality of the movement of the upper in relation to the lower framework, the motion is extremely smooth and far exceeds expectations. Even with such rapid movements as that of $2\frac{1}{6}$ inches in fifteen seconds scarcely any

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trace of uneven motion can be detected, even when the negative has been enlarged four diameters.

The exposures, varying within wide limits, demanded by the changing clearness and brightness of the image on the slit require fairly accurate settings of the micrometer screw for any particular exposure. Experience soon showed that temperature greatly influenced the rate of escape of the oil (sperm) which rate determines the "run." A chart giving working details of the influence of temperature became an immediate necessity. Preliminary observations during adjustment gave some data which put in the form of a table aided in setting; the daily results being added, the table gradually became of greater extent, accuracy, and value. At present a setting of sufficient closeness by means of the chart is thus readily made.

The table consists of a sheet divided into squares: in these the actual times of runs are entered, their position in the table being determined by a vertical scale of temperature and a horizontal scale of micrometer readings. With a full sheet the conditions for a run of any duration can be seen at once. As each square accumulates data, corresponding to a definite temperature and micrometer reading, differences are noticed. These are no greater than might be expected considering the difficulty of timing a passage of the slit, the alteration of focal length, and consequent change of size of the primary image, and the real seasonal change of semi-diameter. The temperature, though taken close to the clepsydra, cannot with certainty be said to represent that of the oil.

The Optical Parts in Relation to the Moving Platform.

The double tube is placed parallel to the long side of the triangular frame, this having previously been set in a north-and-south line. The tube is strongly screwed down on to the framework in such a way that the northern end carrying the two slits overhangs it.

To the south of the collimator and camera objectives is a strong base board also firmly fixed to the framework (Plate 9, fig. 3), and on this are placed the levelling-stands carrying the 6-inch reflector and prism.

The mean position of the optical axis of the collimator tube which carries the primary slit is so adjusted that the latter bisects the solar image formed in the meridian line by the 12-inch objective. In this way the slit can be moved to either side of the solar image to a maximum distance of eleven-twelfths of an inch, and a clear run of the slit across the image, which has a diameter of $2\frac{1}{6}$ inches, can be secured. For obtaining photographs of the prominences on the solar limb this clearness is found to be ample.

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Adjustment of Secondarg Slit on the "K" Line.

Up to the present time the setting of the central portion of the "K" line on the secondary slit has been accomplished by visual observation with the aid of a watchmaker's black eye, but it is hoped that a more satisfactory method will be available when the alterations and additions now in progress are completed. On bright days and with a high sun there is very little uncertainty about setting the line correctly, especially if a spot region be adjusted on the primary slit, so as to produce reversals on the "K" line at the secondary slit. On dull days the "K" region of the spectrum is very faint, and correct setting occupies much time. To control the correctness of the adjustment a photograph with the secondary slit wide open is often taken. This photograph also serves several useful purposes, for from it not only can the verticality of the secondary slit in relation to the spectrum lines be at once observed, but the position of the photographic plate in relation to the focal plane can be checked.

The Taking of the Photograph.

The adjustment of the secondary slit on the "K" reversal being satisfactory it is closed down by a micrometer screw to the desired width. Putting the primary slit in the meridian line through the siderostat and 12-inch lens, the solar image is brought by the siderostat slow motions into the meridian and centred on the slit. The focussing of the image on the slit is accomplished by placing a thin sheet of paper on the slit plate and moving the 12-inch lens until the solar limb, or spot, is quite sharp. In consequence of the brilliancy of the image the observation has to be made through tinted glass. The small shutter behind the primary slit is then closed. The loaded plate-holder is next slid into the carrier, and both secondary slit and carrier are as securely wrapped in velvet as is consistent with the necessary freedom of relative movement during the exposure. Pushing the whole upper framework, and with it the primary slit, to the east of the stationary solar image by the screw with attached handle, described above, the instrument is ready for a "run." The brightness of the image now determines the length of the exposure to be given.

The approximate temperature of the oil in the clepsydra is read by the attached thermometer. This enables the necessary micrometer screw-reading for the length of run to be obtained from the table of data compiled from previous observations.

The screw-plunger adjustment, facilitated by a conveniently placed electric pea lamp which lights the scale and a reading lens, both carried by the upper triangle, is readily made.

The slide of the plate-holder is now withdrawn under its velvet cover, and the signal for a favourable opportunity for

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exposing waited for. This given, the final operations of opening the shutter of the primary slit and releasing the starting-handle are performed. The primary slit then moves uniformly westward, touches and glides through the stationary solar image, the "K" light record being continuously built up on the stationary photographic plate.

The time of transit of the slit across the image is indexed as the "run." Closing the slit shutter and the slide of the plateholder completes the essential instrumental operations.

To obtain a photograph of the prominences on the limb, a longer "run" and the eclipse of the Sun's image by a zinc disc (described above) are necessary.

When these limb photographs are taken it is always attempted to produce a "composite picture" by making an exposure for the disc on the same plate. For the limb picture the disc must be placed vertically and close to, but not touching, the primary slit. Its size is so chosen that it only allows an extremely small portion of the solar image at the limb to fall on the slit plate. Being set in position and the micrometer screw adjusted for the longer "run," the procedure is the same as before.

To maintain the image in position during the necessarily much longer exposure, the siderostat slow motions are used when necessary. After the completion of the exposure for the limb the primary shutter is closed and the instrument is wound over into the initial position. The micrometer screw is then altered to reduce the exposure to that required for the disc picture. The metal disc is then removed, the primary exposure shutter opened, and the slit is allowed to traverse the whole solar image, producing the ordinary "K" disc picture.

The developed result is thus a composite picture in "K" light of prominences at the limb and surface markings.

After many trials it has been found that a "limb" photograph requires on the average sixty times the exposure of that necessary for the "disc" pictures. The plates, which have given the greatest satisfaction throughout, have been the Imperial Ordinary, of the Imperial Dry Plate Company, developed with hydroquinone.

Before proceeding to describe the results obtained, mention may be made of the difficulties that have arisen regarding the use of Taylor lenses. In the first place the focal length of the 12-inch objective is always undergoing alterations from minute to minute, depending on temperature. Thus, for instance, the focal length as determined by a star at night is shorter than that measured by the Sun during the day time.

The tendency is for the focal length to increase for a rise in temperature, but the changes do not vary regularly with regard to the temperature of the room. The presence or absence of the solar beam on the objective, or the passing of a cloud which cuts off the sunlight, are sufficient to cause the focal length to change considerably.

Great care has therefore to be taken to allow the solar beam to fall on the lens for some minutes before taking a photograph and to adjust the focus on the primary slit immediately before making the exposure.

In the case of the limb photographs, when exposures of some minutes are required, this variation is a source of much trouble, and responsible for many unsatisfactory results.

Again the 4-inch Taylor objectives forming parts of the collimator and camera tubes have also been found to vary their focal lengths, though not to such a great extent. This has necessitated a frequent check being made on the position of the focal plane at the secondary slit.

Results.

Up to the present time the instrument has been employed for securing two classes of routine photographs.

(1) Disc photographs in "K" light.

(2) Composite disc and limb photographs also in "K" light.

These latter, though always striven for, were only obtained on the days of more continuous clear weather, and often several were obtained on days of special interest, such as when spots were near the limb.

Examples of these two kinds of pictures are shown in Plate 11, figs. 1 and 2, the former having been taken on 1904 September 20, and the latter on July 19 of the same year.

Dealing in the first instance with the photographs showing the "K" markings on the disc, the following general remarks, gathered from a preliminary examination of all the best plates taken between April and November, may be of interest.

The general feature of the surface of the disc is a universal "mottling" which seems to be made up of a fine mesh of small branching lines. They are not restricted to any zone, but are of the same character in both polar and equatorial regions. On clear days, with good definition and accurate setting of the line on the slit, this mottling becomes very obvious. More conspicuous than the above are the bright and more or less compact patches in middle and low latitudes. They have the appearance of being made up of the mottling, but exaggerated in size and intensity, and the compactness appears to be produced by the filling up of the interspaces with bright patches; in fact in these regions there is a tendency to form a more intense nucleus with radiating arms, and the resemblance to foam traces in deep water disturbed from below is very striking. Plate 12 gives an idea of this apparent building up of a flocculus in the manner above described. It will be seen that there are very frequently long streaky bright portions springing from a central nucleus and having subsidiary ramifications. A three-legged formation with central brightening is a very common type of structure.

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In the majority of cases flocculi exist where no spot is obvious, but spots never appear unless surrounded by these calcium clouds. They resemble and possibly are identical with (in part at least) the faculæ, and in consequence are restricted to the zones of the latter.

When a number of groups appear on the disc together the arrangement into equatorial belts is very pronounced. Their distribution in longitude is intermittent more than continuous (see Plate 11), but this may not be the case at other phases of the sun-spot cycle.

With regard to the relation of spots to these calcium clouds it is noticed that the former appear more generally near the head of or precede the apparently trailing masses of the latter with respect to the solar rotation. Typical examples of this relationship are given in Plate 13. There seems to be little doubt that the position of spots in flocculi is not due to chance, but that there is some physical reason dominating the cause and effect in their relative positions. This is a point that requires investigation when several complete series of photographs, extending over semi-rotation periods of the Sun, have been secured. Such photographs will probably throw much light on the various phases in the life-history of a spot group, and classifications, such as that put forward by Father Cortie, S.J.,* may possibly be extended and explained.

Turning now to the results gathered from an examination of the composite pictures showing the disc and limb taken at two consecutive exposures on one plate—an example of which is illustrated in Plate 11, fig. 2—the following are the chief points noticed :

Prominences in all latitudes, even near the solar poles, give strong images in "K" light.

The frequent occurrence of prominences outside the zone of flocculi during this period did not apparently alter in any way the regular mottling on the disc in those latitudes.

When an intense flocculus was on or near the limb it was not always accompanied by a large prominence at the same position angle or even in its neighbourhood. The impression gathered from a series of photographs taken especially for this purpose was that prominences were generally independent of flocculi, and *vice versa.*

On continuously fine days, when several composite photographs could be secured at intervals, an opportunity was afforded of studying the changes in the form of prominences from hour to hour.

Two examples of such changes are here described and illustrated in Plate 14, figs. 1 and 2. Those in fig. 1 were taken on 1904 July 14 at 11^{h} 8^{m} A.M. and 12^{h} 8^{m} P.M. G.M.T. It will be noticed that during the interval of time between the

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* *Astrophysical Journal*, vol. xiii., 1901, p. 260.

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two photographs, about one hour, a startling change occurred to the largest prominence; and not only has its height been considerably increased, but its form has altered. The material forming the prominence seems to have been ejected from the chromosphere and then to have met a strong current moving polewards (*i.e.* from left to right in the figure), which has thrown this material in that direction. The change of height from 50,000 to 60,000 miles in this interval gives an approximate rate of movement away from the chromosphere of about two and a half miles per second.

It will be noticed that the other large prominence (No. 5) in the same figure has during that interval nearly disappeared in spite of its exceeding intensity in the first photograph. In the second case (Plate 14, fig. 2) we have an enormous prominence in the spot zone that was secured on 1904 July 19, the upper and the lower photographs having been taken at 11^h 44^m A.M. and 3^h 52^m P.M. G.M.T. respectively. This prominence was situated in the S.E. quadrant, the higher portions being directed towards the equator. The approximate greatest heights and lengths on the two photographs were as follows :

h m	Length.	Height.
11 44	192,000	55,000
3 52	216,000	60,000

[To show the complete record both on the limb and disc at the first of these times, see Plate 11, fig. 2.]

Although the interval here is over four hours, there is not such a considerable alteration in form as that recorded in Plate 14, fig. 1.

In many of the remarks relating to the disc and limb pictures it must not be forgotten that they only apply to the photographs secured in 1904. At any other time, such as a sun-spot minimum or maximum, the solar activity is different, and therefore changes of another kind may be apparent. Thus, for instance, the mottling on the disc may be more, or it may be less, pronounced than it was in 1904, while the flocculi may be more connected in longitude than was the case in 1904, when they were intermittently distributed in longitude.

In conclusion, I should like to express my obligations to the Director of the Observatory, Sir Norman Lockyer, for allowing me to prepare the present paper for communication to the Society. Messrs. W. Moss and T. F. Connolly assisted me in taking the photographs, and Mr. J. P. Wilkie in preparing the plates.

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Description of the Plates.

PLATE 9.

FIG. 1.—The north ends of the collimator and camera tubes showing the two slits, the plate holder carrier and metal disc in position for a limb photograph (p. 476).

FIG. 2.—A view of the curved secondary slit showing the screw adjustments (p. 476).

FIG. 3.—The south ends of the collimator and camera showing the arrangement of the reflector and prism (p. 478).

FIG. 4.—The "H" and "K" portion of the solar spectrum (enlarged twice) illustrating the curvature of the lines. The sun-spot absorption is also shown and the reversals of the "H" and "K" lines near the spot region (p. 478).

PLATE 10.

General view of the spectroheliograph (p. 478).

PLATE 11.

FIG. 1.—Sun's disc in "K" light as photographed on 1904 September 20 at 10^h 42^m A.M. G.M.T. Exposure 73^s. Enlarged about $1\frac{1}{2}$ time (p. 483).

FIG. 2.—Composite photographs of Sun's disc and limb in "K" light as photographed on 1904 July 19 at 11^h 45^m A.M. G.M.T. Exposure for disc 18^s, and for limb 18^m. Enlarged about $1\frac{1}{2}$ time (p. 483).

PLATE 12.

Flocculus region to illustrate how these large "K" clouds are built up by the amalgamation of the smaller but somewhat intense "mottling." The dates on the right-hand side correspond to the days on which the photographs were taken. The east limb of the Sun is towards the right. Enlarged about four times (p. 483).

PLATE 13.

Typical cases of spots preceding the main flocculus regions in the direction of the solar rotation. The dates on the right-hand side correspond to the days on which the photographs were secured. The east limb of the Sun is on the right-hand side in each case. Enlarged about four times (p. 484).

PLATE 14.

Enlarged photographs of "K" prominences illustrating changes after brief intervals of time.

FIG. 1.—Negatives taken 1904 July 14. The upper photograph was secured at 11^h 5^m and the lower one at 12^h 30^m P.M. G.M.T.

FIG. 2.—Negatives taken 1904 July 19. The upper and lower photographs were taken at 11^h 45^m A.M. and 3^h 59^m P.M. G.M.T. respectively. Enlarged about four times (pp. 484, 485).

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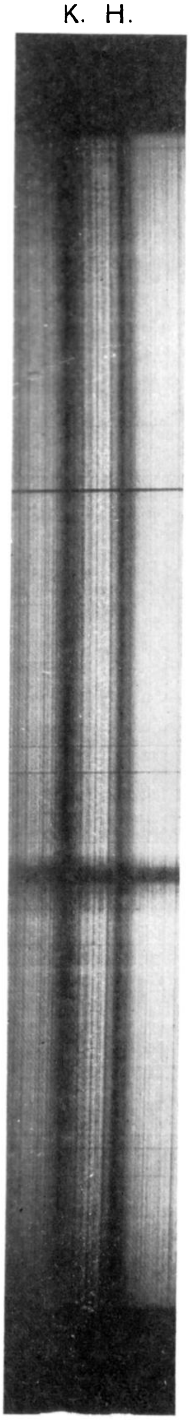

FIG. 4.

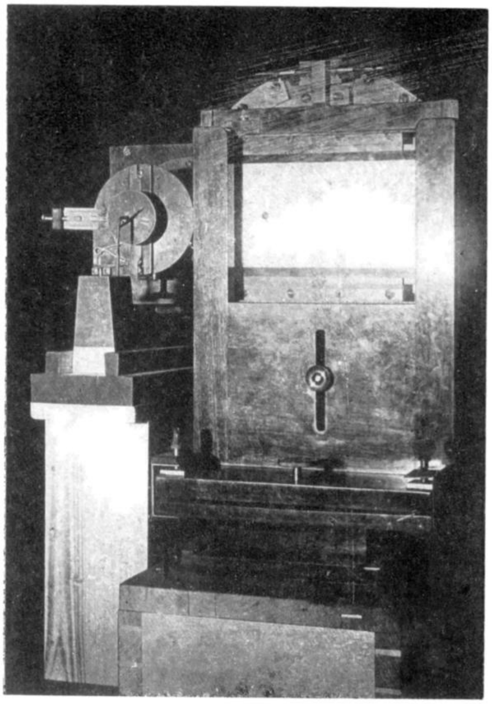

FIG. I.

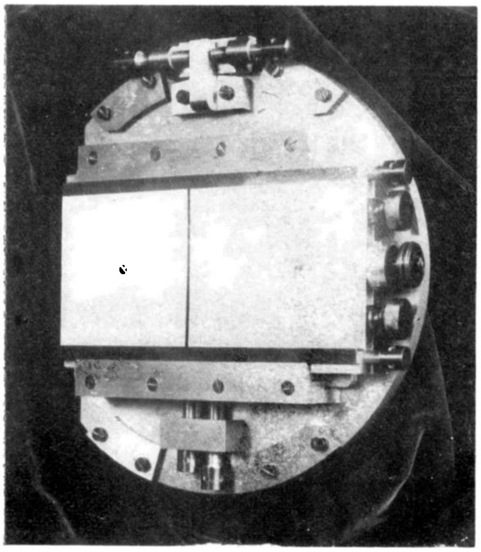

FIG. 2.

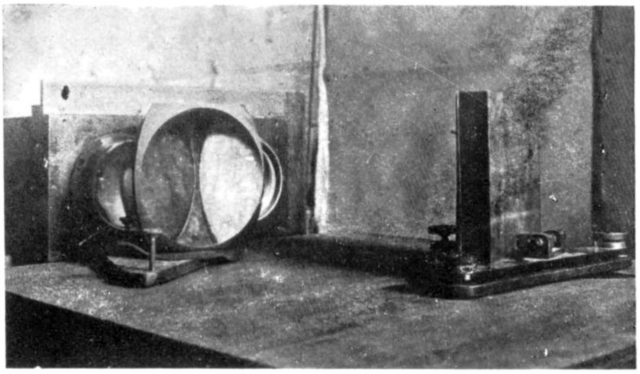

FIG. 3.

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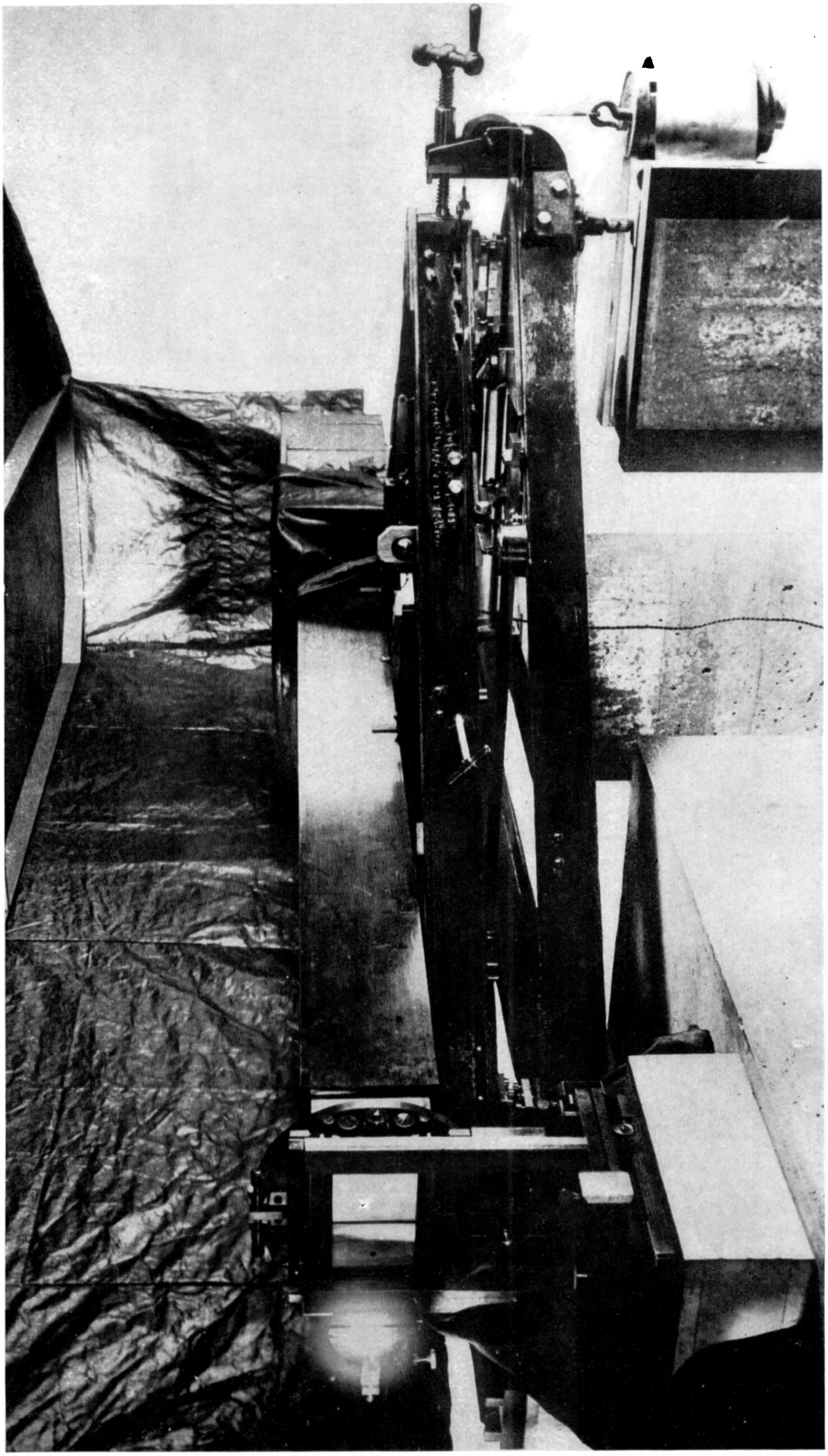

GENERAL VIEW OF SPECTROHELIOGRAPH.

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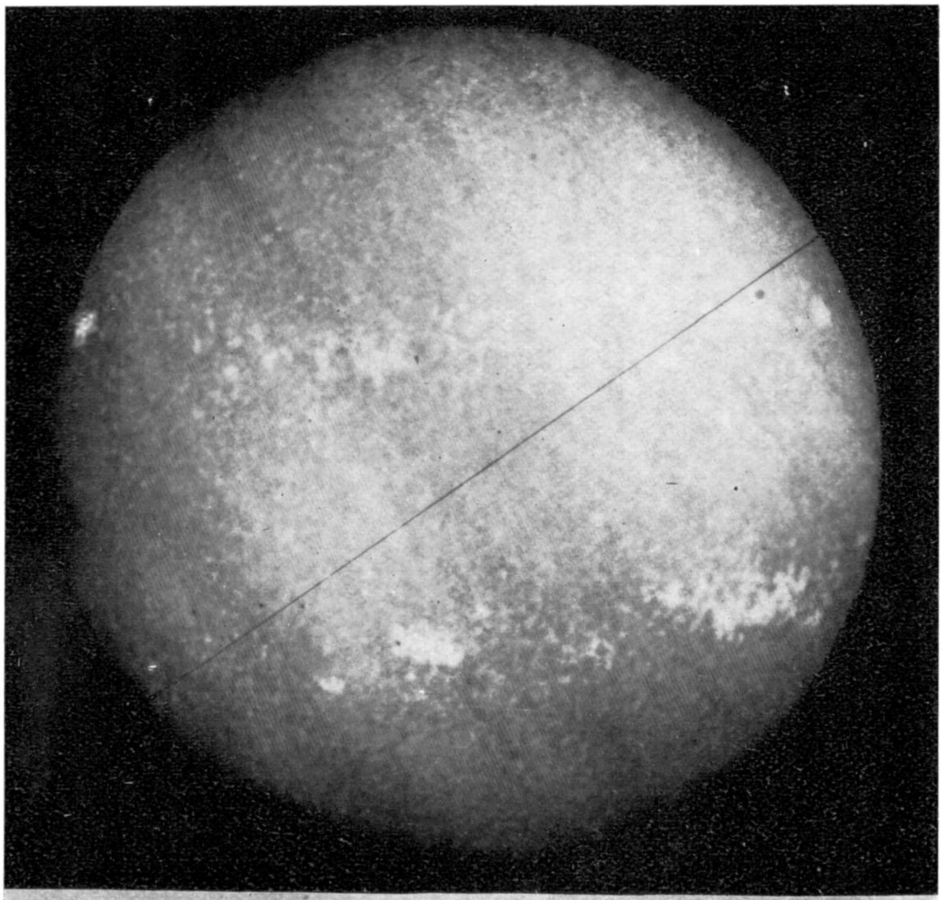


FIG. 1.

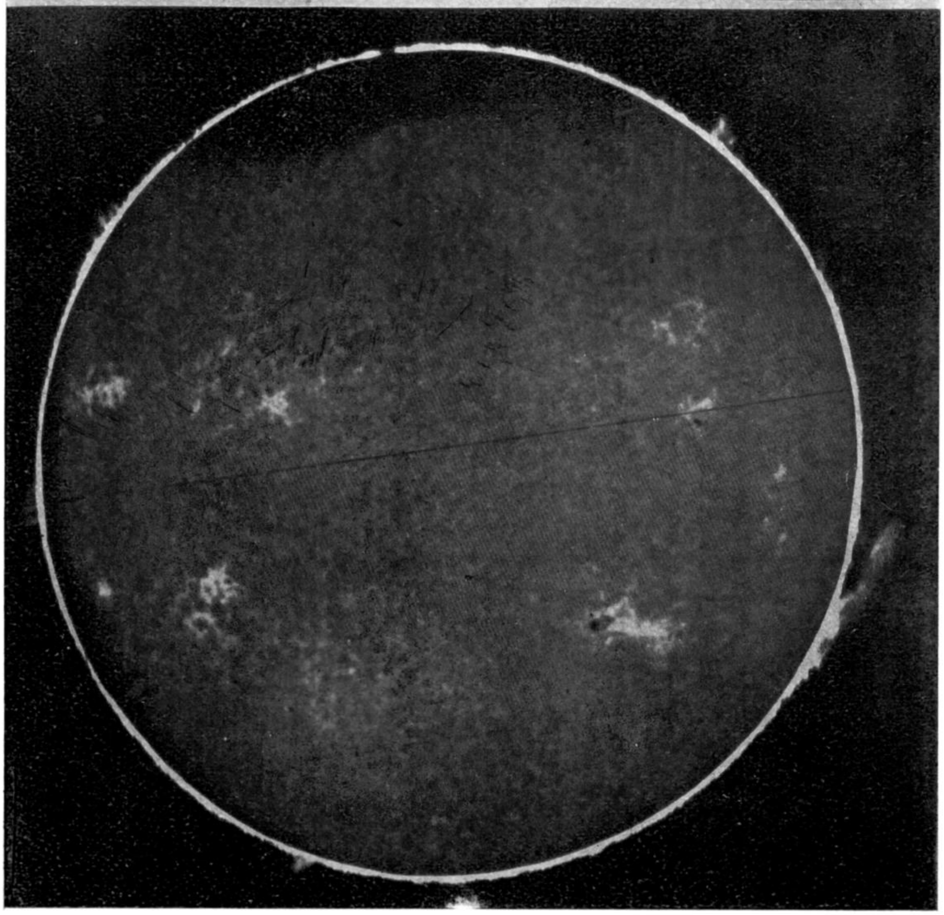
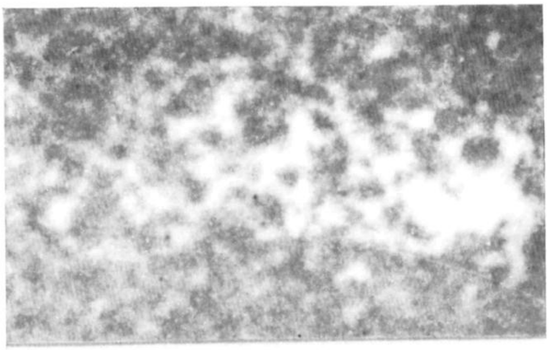
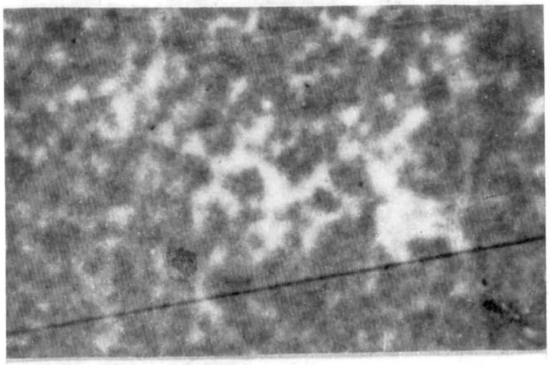


FIG. 2.

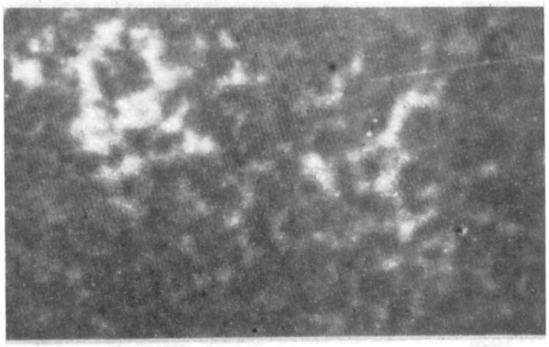
1905MNRAS..65..483L



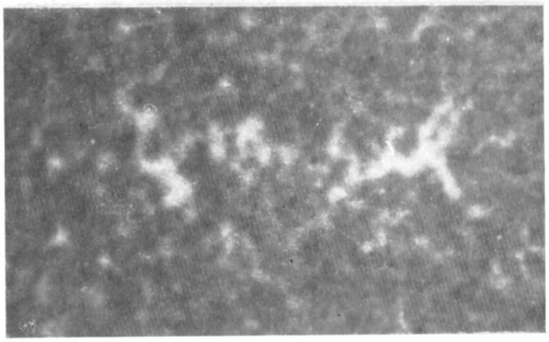
1904.
May 23.



Aug. 2.

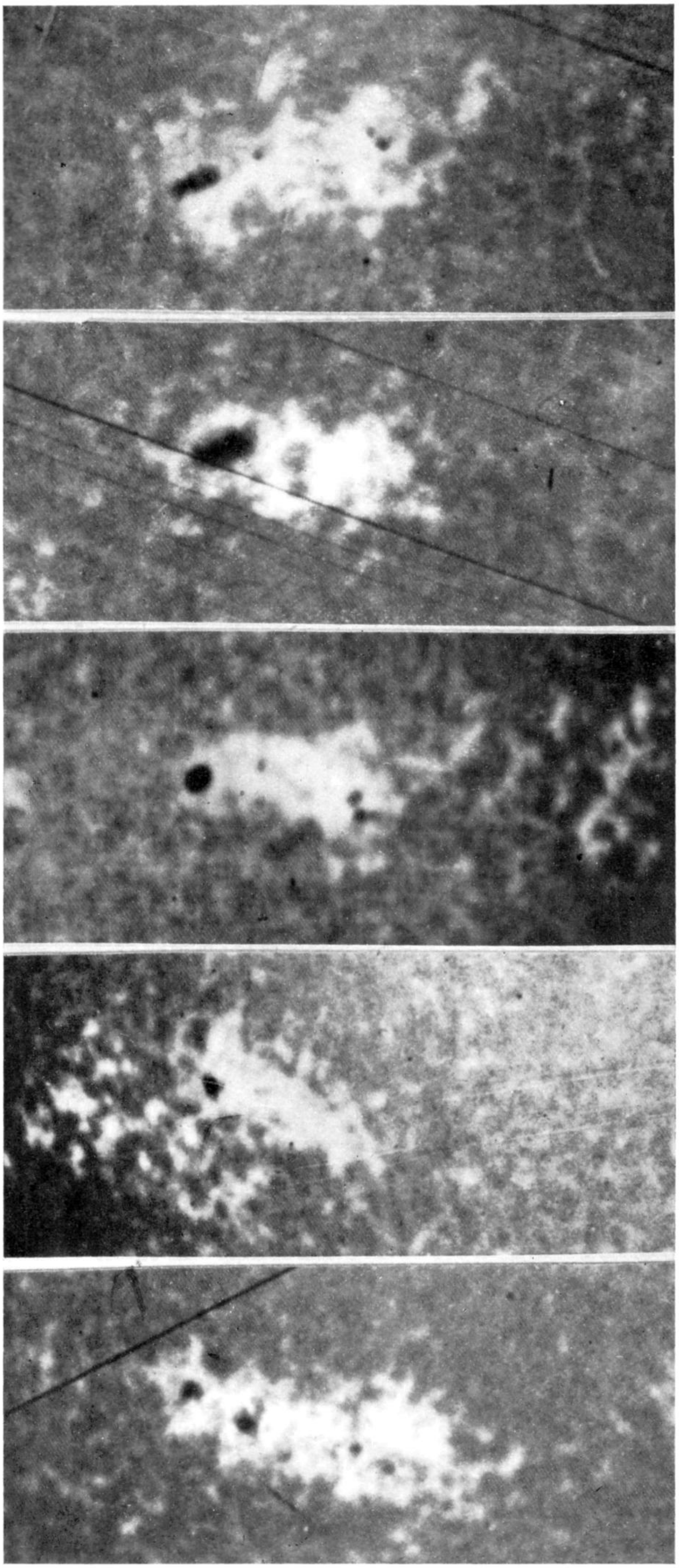


Sept. 26.



Sept. 26

1905MNRAS..65..483L



MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY. VOL. LXV PLATE 14.

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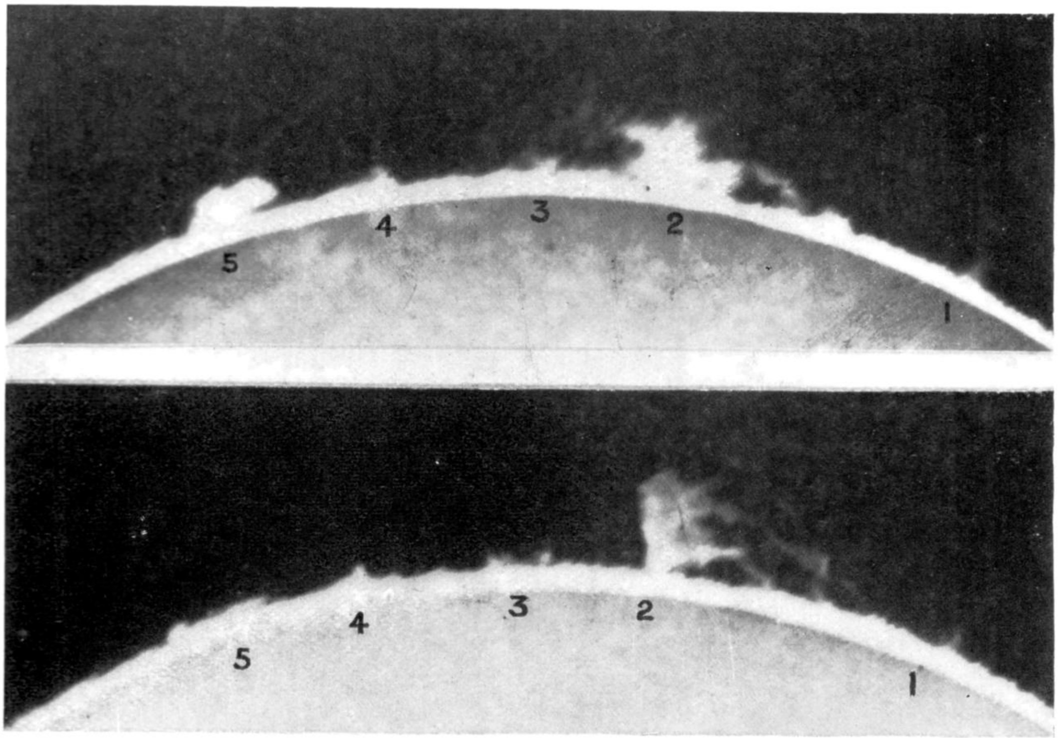

FIG. 1.

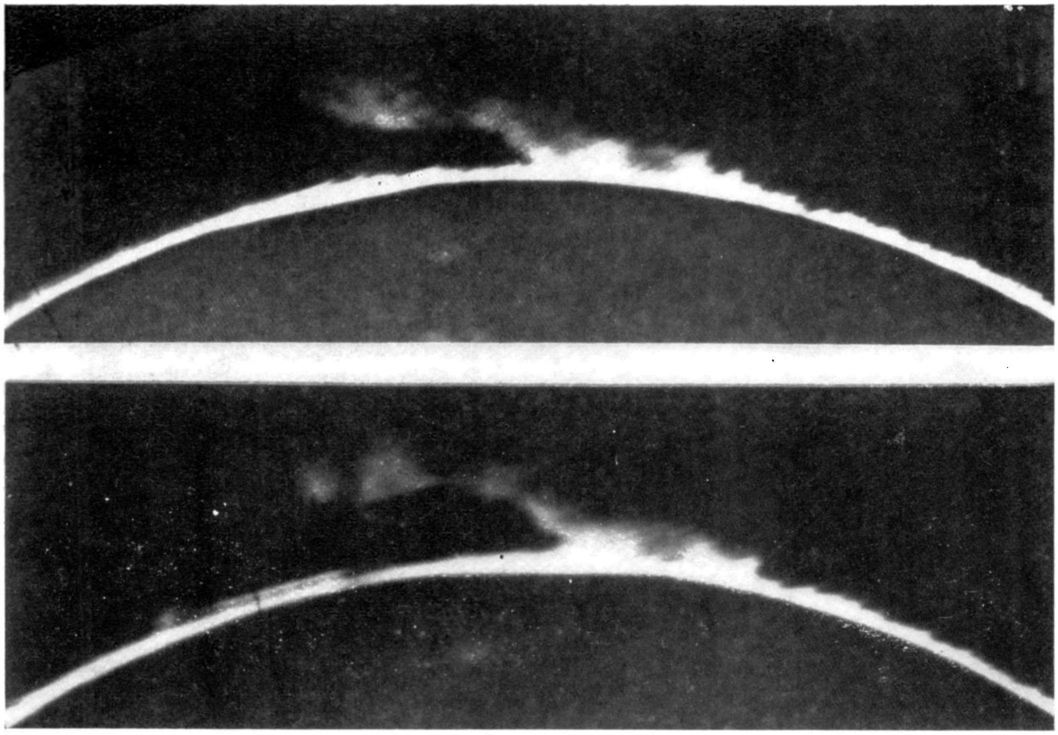

FIG. 2.